

Diversity Receiver And Diversity Reception Method

Background of the Invention

Field of the Invention

5 The present invention relates to a diversity receiver and diversity reception method performed in a communication device using a CDMA (code division multiple access) method.

Description of the Related Art

10 In a PDC-based mobile communication system, mobile stations and base stations employing antenna diversity are generally used. The PDC method adopts TDMA (time division multiple access) and so an antenna that is in an optimum
15 reception environment is selected from plural antennas, based on the received field strength in each idle reception interval other than the present slot. Meanwhile, antenna diversity has been proposed also in CDMA techniques. (For example, in Reference 1: JP-A-2001-251230, Reference 2:
20 JP-A-2001-127675, and Reference 3: JP-A-2000-503184.)

 However, antenna diversity reception in CDMA is more difficult to achieve than PDC for the following reason. In CDMA, the received signal is code-divided. Therefore, the received field strength of the signal cannot
25 be measured unless the received signal is decoded even to

baseband. Therefore, the optimum reception environment cannot be judged. Furthermore, in CDMA, the received signal is discriminated from received signals from other users by code division. The received signal is not time-divided
5 unlike in TDMA. Consequently, the received signal must be kept received and decoded. That is, if one tries to implement a method of TDMA for switching the used antenna during one reception and measuring the strengths at both antennas, the received data will be lost during switching
10 of the antenna.

For the reasons described so far, it is necessary that circuits for encoding the received signal to baseband be equal in number with the antennas to realize antenna diversity in CDMA. Another problem is that the received
15 data will be lost at the timing of antenna switching. These problems must be taken into account. Furthermore, in CDMA, it is only possible to receive signals from a single base station in standby mode, because the signals are code-divided differently for different base stations and the
20 mobile station receives using a code for a sole corresponding base station.

In JP-A-2001-251230 (Reference 1), a receiver and method is proposed which is capable of selecting two antennas providing optimum receive characteristics out of
25 plural antennas for CDMA mobile communication systems. To measure the received field strength in CDMA, it is

necessary to decode the received signal even to baseband as mentioned previously. The problem is that a scheme that does not use plural decoding subsystems but compares the strengths by switching the antenna cannot be achieved.

5 Where plural decoding subsystems are provided, there is the problem that the circuit scale is increased.

Furthermore, in JP-A-2001-127675 (Reference 2), a method of making the CDMA base station use antenna diversity is proposed. With this method, all the existing
10 subsystems need to be modified, thus involving exorbitant cost. To avoid this, a method permitting the mobile station alone to cope with the situation is preferably adopted.

Summary of the Invention

The present invention has been made in view of the
15 foregoing problems and situations with the prior art. It is an object of the invention to provide a receiver and method for diversity reception used in a CDMA communication system, the receiver and method being characterized in that the used antenna can be switched with antenna diversity
20 using only one decoding subsystem without losing received data. It is another object to provide a receiver and method for diversity reception characterized in that diversity can be accomplished by each mobile station alone without modifying the whole system including base stations.

25 The diversity receiver according to the present

invention achieves above-described objects and is used in a CDMA communication system, the receiver having first and second antennas for receiving signals from a base station, a received field strength-measuring unit for measuring the received field strength produced at the first or second antenna by the intermittent signals sent out every designated slot cycle from the base station in standby mode, an information storage unit for storing information (hereinafter referred to as "field strength information") about the received field strengths of the intermittent signals received by the first and second antennas for the individual antennas, and an antenna selection unit for selecting the antenna at a higher received field strength based on the information about the reception environment of each antenna stored in the information storage unit immediately prior to start of a phone conversion when a transition is made from standby mode to the conversation.

Since the information storage unit stores the received field strengths of the individual antennas in this way, the used antenna can be switched with antenna diversity. Communications can be performed with an antenna placed in a better reception environment. Furthermore, only one decoding subsystem is necessary, because the information storage unit stores the received field strengths at the individual antennas. Antenna diversity can

be accomplished without increasing the circuit scale or complicating the circuit.

Furthermore, in the diversity receiver according to the invention, the above-described antenna selection unit
5 alternates the used antenna every said designated slot cycle in standby mode. The received field strength-measuring unit stores information about the received field strength at the antenna selected by the antenna selection unit in the information storage unit. In this way, the
10 measurement of the received field strength is performed while switching the two antennas alternately every designated slot cycle. Consequently, the received data is not lost even in CDMA.

In addition, in the diversity receiver according to
15 the invention, the antenna selection unit adjusts the ratios at which the antennas are respectively selected according to the received field strengths at the antennas in standby mode. The received field strength-measuring unit stores the field strength information about the antenna
20 selected by the antenna selection unit in the information storage unit. In this way, the ratios at which the antennas are respectively selected are adjusted. Consequently, the receiver can wait in a better reception environment.

The diversity receiver according to the invention
25 is fitted with a base station information acquiring unit for acquiring information about a base station (hereinafter

referred to as "base station information") included in a signal received from the base station and for storing the information in the information storage unit. The first antenna receives the signal sent from a first base station.

5 The base station information acquiring unit acquires base station information about the first base station and stores the information in the information storage unit. The second antenna receives the signal sent from a second base station. The base station information acquiring unit

10 acquires base station information about the second base station and stores the information in the information storage unit. The antenna selection unit selects the antenna at a higher received field strength based on the information about the reception environments of the

15 antennas stored in the information storage unit and on the base station information immediately prior to start of a phone conversation when a transition is made from standby mode to the conversation. Accordingly, diversity can be accomplished with a mobile station alone without modifying

20 the whole system including base stations.

A method of diversity reception according to the present invention is performed by a diversity receiver used in a CDMA communication system, the receiver being fitted with first and second antennas for receiving signals from

25 base stations. This method comprises the steps of: measuring the received field strength produced at the first

or second antenna by an intermittent signal sent from a base station every designated slot cycle in standby mode; storing information (hereinafter referred to as "field strength information") about the received field strengths produced by the intermittent signal received by the first and second antennas for the individual antennas; and selecting the antenna at a higher received field strength based on the environment information about each antenna immediately before a phone conversation is started when a transition is made from standby mode to the conversation.

In the method of diversity reception according to the invention, in the aforementioned step of selecting the antenna, the antennas are alternately selected every said designated slot cycle.

Furthermore, in the method of diversity reception according to the invention, in the aforementioned step of selecting an antenna, the ratios at which the antennas are respectively selected are adjusted according to the received field strengths at the antennas in standby mode.

Moreover, the method of diversity reception according to the invention has the step of acquiring information (hereinafter referred to as "base station information") about a base station, the information included in a signal received from the base station. The step of acquiring base station information comprises a first acquiring base station information about a first base

station included in a signal sent from the first base station and received by the first antenna and second acquiring base station information about a second base station included in a signal sent from a second base station and received by the second antenna. In the
5 aforementioned step of selecting the antenna, the antenna is selected at a higher received field strength based on information about the reception environment of each antenna and on information about each base station immediately
10 prior to start of a phone conversation when a transition is made from standby mode to the conversation.

Brief Description of the Drawings

Fig. 1 is a block diagram showing a diversity receiver according to one embodiment of the present
15 invention;

Fig. 2 is a diagram illustrating a first pattern of intermittent reception;

Fig. 3 is a diagram illustrating a second pattern of intermittent reception; and

20 Fig. 4 is a diagram illustrating a transition from standby mode (intermittent reception) to a phone conversation.

In the drawings, a reference numeral 1 refers to a
25 first antenna; 2 to a second antenna; 3 to an antenna

selector switch; 4 to a shared device; 5 to a transmit subsystem; 6 to a receive subsystem; 7 to a synchronous detector; 8 to a received field strength-measuring unit; 9 to a received data decoder; 10 to a message-processing unit; 11 to an information storage unit; and 12 to an antenna switching control unit.

Detailed Description of the Preferred Embodiments

Receivers and methods for diversity reception in accordance with embodiments of the present invention are hereinafter described in detail with reference to the drawings. Fig. 1 is a block diagram showing a diversity receiver according to one embodiment of the invention. As shown in this figure, the diversity receiver according to the present embodiment is composed of a first antenna 1, a second antenna 2, an antenna selector switch 3 corresponding to the antenna selection unit referred to in the attached claims, a shared device 4, a transmit subsystem 5, a receive subsystem 6, a synchronous detector 7, a received field strength-measuring unit 8 corresponding to the received field strength-measuring unit referred to in the claims, a received data decoder 9, a message processing unit 10 corresponding to the base station information acquiring unit referred to in the claims, an information storage unit 11 corresponding to the information storage unit referred to in the claims, and an

antenna switching control unit 12.

The components possessed by the diversity receiver according to the present embodiment are described below.

First, the antenna selection switch 3 makes a
5 switch between the first antenna 1 and second antenna 2 to
achieve antenna diversity. The shared device 4
discriminates the signal sent from the transmit subsystem 5
from a signal received by the first antenna 1 or second
antenna 2. The transmit subsystem 5 modulates or otherwise
10 processes a baseband signal of Rx I/Q. The receive
subsystem 6 converts the received signal discriminated by
the shared device 4 into a baseband signal of Rx I/Q.

The synchronous detector 7 synchronously detects
the baseband signal converted by the receive subsystem 6.
15 Furthermore, the synchronous detector 7 sends information
about timing at which reception is made by the antennas 1
and 2 to the information storage unit 11. The received
field strength-measuring unit 8 measures the received field
strength (RSSI (received signal strength indicator) value)
20 from the baseband signal. Information for RF control is
created from this received field strength. The received
field strength-measuring unit 8 sends the information about
the received field strength and the information about the
RF control to the information storage unit 11.

25 The received data decoder 9 decodes the baseband
signal synchronously detected by the synchronous detector

7. The message-processing unit 10 decodes messages from base stations (not shown). Furthermore, the message-processing unit 10 sends information about a base station (hereinafter referred to as "base station information") to
5 the information storage unit 11, the information included in a message received from the base station.

In addition, the information storage unit 11 stores the field strength information, reception timing information, RF control information, and base station
10 information sent from the synchronous detector 7, received field strength-measuring unit 8, and message-processing unit 10 in information tables 11a and 11b provided for the antennas, respectively. The antenna switching control unit 12 controls operation of the antenna selector switch 3 to
15 select the used antenna based on the field strength information obtained from the information storage unit 11.

The operation of the diversity receiver (i.e., method of diversity reception) according to the present embodiment is next described.

20 First, the operation in standby mode (intermittent reception) is described. In CDMA standby mode (intermittent reception), an intermittent signal sent from a base station at regular intervals (slot cycles) is received by a mobile station. Therefore, the mobile station performs its receive
25 operation every slot cycle. After receiving the intermittent signal from the base station, the station

sleeps up to the next receive operation. These receive operation and sleep operation are repeated every slot cycle.

Fig. 2 is a diagram illustrating a first pattern of intermittent reception. In the illustrated first pattern, the antennas 1 and 2 are switched alternately. That is, in the first slot cycle, when the receiver is in the receive mode, the antenna selector switch 3 receives a switching control signal from the antenna switching control unit 12 and selects the first antenna 1. Then, the information storage unit 11 sends reception timing information, field strength information, RF control information, and base station information and returns these kinds of information back to the synchronous detector 7, received field strength-measuring unit 8, and message-processing unit 10, all of these kinds of information corresponding to the first antenna 1. A setup is made such that reception is started from a state corresponding to the first antenna 1. After receiving the intermittent signal from the base station, the receiver goes to sleep.

In the next slot cycle, when the receiver is in the receive mode, the antenna selector switch 3 receives a switching control signal from the antenna switching control unit 12 and selects the second antenna 2. Then, the information storage unit 11 sends receive timing information, field strength information, RF control

information, and base station information and returns these kinds of information to the synchronous detector 7, received field strength-measuring unit 8, and message-processing unit 10, these kinds of information
5 corresponding to the second antenna 2. A setup is made such that reception can be started from a state corresponding to the second antenna 2. After receiving the intermittent signal sent from the base station, the receiver goes to sleep. The antennas 1 and 2 are switched alternately every
10 slot cycle in this way. The used antenna can be switched without losing the received data. Furthermore, it is only necessary to have only one decoding subsystem. In consequence, antenna diversity can be accomplished without increasing the circuit scale of the diversity receiver or
15 complicating the circuit.

Fig. 3 is a diagram illustrating a second pattern of intermittent reception. In the illustrated second pattern, the ratios at which the antennas 1 and 2 are selected are adjusted according to the received field
20 strengths, respectively, at the antennas 1 and 2. That is, the antenna switching is adjusted such that the antenna at a higher received field strength is selected more frequently. For example, where the received field strength at the first antenna 1 is higher than the strength at the
25 second antenna 2, the antenna switching is done in 2:1 ratio, i.e., reception using the first antenna 1 is

performed twice and reception using the second antenna 2 is performed once. Latitude may be provided in using the second pattern. For instance, the ratios may be varied according to the difference in the received field strength.

5 By adjusting the ratios at which the antennas are respectively selected in this way, the standby operation can be performed in a better reception environment during the standby mode (intermittent reception).

A transition from standby mode (intermittent
10 reception) to a phone conversation is next described by referring to Fig. 4, which illustrates the transition from standby mode (intermittent reception) to the phone conversation. In the illustrated embodiment, the received field strength at the first antenna 1 is higher than the
15 strength at the second antenna 2, and the phone conversation is started when the second antenna 2 is selected in the standby mode. In this embodiment, during standby mode immediately prior to start of a phone conversation, the antenna (second antenna 2) at a weaker
20 received field strength is selected. Therefore, to perform a phone conversation in a better reception environment, the used antenna is switched from the second antenna 2 to the first antenna 1. This switching is done during a transition from standby mode to phone conversation. Therefore, the
25 antenna in a better environment, i.e., the antenna at a higher received field strength, is selected based on

information about the reception environment immediately prior to start of a phone conversation. Then, a transition is made from the standby mode to the conversation. Consequently, it is possible to shift to the conversation
5 without losing the received data.

Where a phone conversation is started while the second antenna 2 is selected as mentioned previously, the receiver may wait one slot cycle and switch to a phone conversation during the next selection of the first antenna
10 1 (when reception is being performed by the antenna at a higher received field strength) without making a switch from the second antenna 2 to the first antenna 1 during a transition from standby mode to phone conversation.

A method of diversity reception in which signals
15 are received from two base stations in standby mode is next described. In CDMA, if a mobile station in standby mode registers its location with a base station, a call is made to a mobile station within the zone where plural base stations including the base station with which the
20 registration has been made perform services. That is, as long as within the zone, the mobile station can hold the standby mode without the need to register its location. Using this scheme, a method of diversity in which signals are received from two base stations is accomplished.

25 During reception with the first antenna 1, various kinds of information about a base station a obtained from

the message-processing unit 10 are saved in the information table 11a. During reception with the second antenna 2, various kinds of information about a base station *b* are saved in the information table 11b. At this time, if the zones of the base stations *a* and *b* overlap, both base stations *a* and *b* can make a call to the mobile station. Meanwhile, the mobile station switches the base station by switching the antennas 1 and 2 alternately every slot cycle and so the mobile station can receive calls from both base stations *a* and *b*.

Where different base stations are used, different signal paths for transmission and reception and different RF wave environments are used. Therefore, highly effective diversity can be accomplished. Accordingly, diversity can be realized with a mobile station alone without modifying the whole system including base stations. Furthermore, the connectivity to each base station can be improved greatly. In a case where the antennas 1 and 2 use different zones of receiving base stations, however, only one base station exchanges calls. Consequently, it is impossible to switch the used antenna to the antenna at a higher received field strength even when a transition is made from standby mode to phone conversation.

As described so far, the inventive receiver and method for diversity reception can accomplish antenna switching exploiting antenna diversity because the

information storage unit stores the received field strengths at the individual antennas. Communication can be performed with the antenna located within a better reception environment. Furthermore, only one decoding
5 subsystem needs to be fitted because the information storage unit stores the received field strengths at the individual antennas. Hence, antenna diversity can be accomplished without increasing the circuit scale or complicating the circuit.

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